ISSN: 2347-7431

EPRA International Journal of Climate and Resource Economic Review

-Peer Reviewed Journal

Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

A COMPARATIVE ANALYSIS OF SUSTAINABLE PRACTICES: CALIFORNIA'S CAP-AND-TRADE PROGRAM AND GERMANY'S 'ENERGIEWENDE' POLICY

Prince Asante

Graduate Student, Eastern Illinois University, Faculty of Business and Technology
Department of Sustainability

Article DOI: https://doi.org/10.36713/epra19505

DOI No: 10.36713/epra19505

ABSTRACT----------

This study explores two strategies used to tackle climate change and promote sustainability which are California's Cap-and-Trade program and Germany's Energiewende policy. Both aim to reduce greenhouse gas emissions but use different approaches. California's Cap-and-Trade program is like a marketplace where companies can buy and sell the right to pollute within strict limits, encouraging businesses to adopt cleaner practices. On the other hand, Germany's Energiewende focuses on government-led efforts to shift away from fossil fuels and nuclear power toward renewable energy like wind and solar. The study compares these approaches, highlighting their successes and challenges. California's system is cost-effective and flexible but has been criticized for not doing enough to improve air quality in vulnerable communities. Germany's policy has driven significant renewable energy growth and job creation but has led to higher energy costs for some citizens. This study argues that there is no perfect solution to sustainability. Countries can therefore learn from each other's successes and failures to create better policies to tackle climate change while balancing environmental, social, and economic goals.

KEYWORDS: *Sustainability, Climate Change, Cap-and-Trade, Energiewende, Renewable Energy.* ----------

INTRODUCTION

The global quest to achieve sustainability has necessitated the initiation and implementation of diverse policies and practices in different places and organizations to address the current problems posited by environmental degradation and climate change. As Vann Yaroson et al., (2024) note, the urgency of these efforts is underscored by the need to align with the United Nations Sustainable Development Goals (SDGs) and to create resilient, environmentally conscious economies. On this basis, this essay presents a comparative analysis of two significant sustainable initiatives: California's Cap-and-Trade program, and Germany's 'Energiewende' policy. These cases exemplify the varied approaches to sustainable development and energy transition in different parts of the world. Specifically, California's Cap-and-Trade program represents a market-based approach to emissions reduction (California Environmental Protection Agency, 2015; Center for Climate and Energy Solution, n.d.), while Germany's 'Energiewende' policy embodies a more direct governmental intervention strategy focused on transitioning to renewable energy sources (Federal Ministry for Economic Affairs and Climate Action, 2015). However, both initiatives reflect the growing recognition that sustainable practices are essential for long term economic and environmental viability. This analysis will explore the key features, motivations, and impacts of these two initiatives, drawing comparisons and offering insights into their effectiveness in promoting sustainable development. By doing this, an insight could be generated into the diverse ways through which sustainability goals could be achieved as well as contributing to the ongoing dialogue on effective climate change mitigation strategies.

OVERVIEW OF THE TWO INITIATIVES

California's Cap-and-Trade Program

California's Cap-and-Trade program was initiated in 2006 when California's legislature approved Assembly Bill 32 (AB 32) which set the State's Green House Gas (GHG) reduction target (Holliman and Collins, 2023). However, the program became operational in 2013 (California Environmental Protection Agency, 2015). According to the University of California's Center for Law, Energy and Environment, (n.d.), and the Center for Climate and Energy Solution, (n.d.), the climate target of the program hovers around three important goals which are first, to reduce greenhouse gas (GHG) emissions to 1990 levels by 2020, second, to reduce GHG

ISSN: 2347-7431
EPRA International Journal of Climate and Resource Economic Review
-Peer Reviewed Journal
Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

emission to 40 percent below 1990 levels by 2030, and lastly, to reduce GHG to 80 percent below 1990 levels by 2050. The California Air Resource Board (CARB) is the institution mandated under the AB 32 bill to run this program to help achieve the GHG reduction targets of the State (Holliman and Collins, 2023; University of California's centre for law energy and Environment, n.d.). Under this program, CARB establishes a statewide limit on the sources responsible for 85 percent of California's greenhouse gas emissions and creates a number of credits under the cap. Greenhouse gas emissions covered under the program include carbon dioxide, hydrofluorocarbons, nitrogen, perfluorocarbon, methane, and trifluoride, among others (Basseches, 2021). If an entity, therefore, produces GHG emissions as a result of its activities, such as power production, manufacturing, or petroleum refining, it must comply with the program by acquiring allowances (or credits) for every metric ton of carbon dioxide equivalent they emit, creating a financial incentive to reduce emissions (California Environmental Protection Agency, 2015; University of California's centre for law energy and Environment, n.d.). These allowances are permitted to be traded enabling companies to buy, sell, or bank these allowances as part of a flexible market-based mechanism (Center for Climate and Energy Solution, n.d.). The allowances are distributed by two major means: free allocation, and quarterly auctions (Center for Climate and Energy Solution, n.d.). Free allocation involves the issuance of allowances or credits for free to certain industries like electric utilities, industrial facilities, and natural gas utilities (California Air Resource Board, n.d.-a). This is meant to help the industries stay competitive while ensuring sustainability and to also prevent "carbon leakage," where companies may relocate to certain regions with lenient environmental laws (California Air Resource Board, n.d.-a). Most allowances are not given away for free and are therefore sold through the quarterly auctions in which businesses participate by bidding to buy allowances, with a minimum price, called the auction floor price, set to prevent allowances from being undervalued (California Air Resource Board, n.d.-a; Center for Climate and Energy Solution, n.d.). The auction process produces a clearing price that all successful bidders pay (Center for Climate and Energy Solution, n.d.).

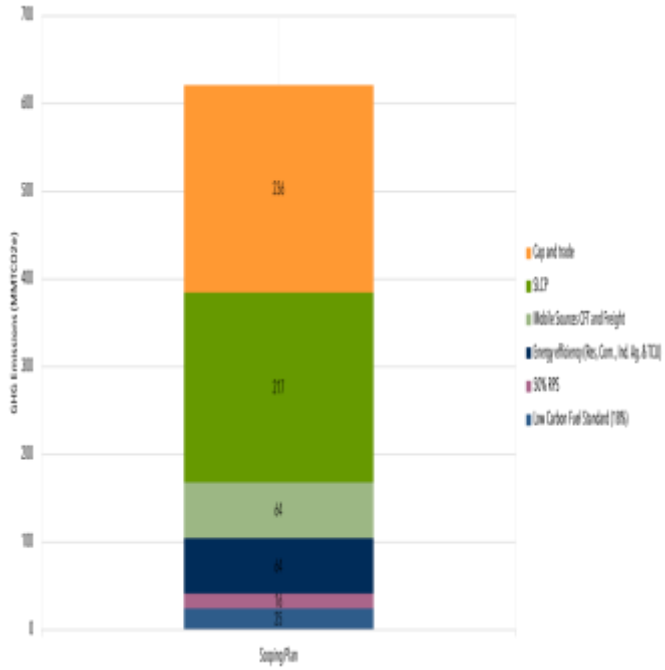
In addition to using allowances, businesses can use a small number of offsets to meet their compliance requirements. Offsets are like "credits" earned by funding projects that reduce or remove greenhouse gas emissions outside the industries covered by the program (California Air Resource Board, n.d.-b). For example, a business might support a reforestation project that absorbs carbon dioxide or a methane capture system at a landfill. By doing this the business could receive some credits which could be used to offset future excess emission costs. Although offsets are a cheaper alternative to allowances and help businesses lower their costs while still contributing to environmental goals, there’s a limit that companies can only use offsets for up to 8% of their total compliance needs (California Air Resource Board, n.d.-b). This rule ensures that most emissions reductions happen directly within the industries regulated by the program, keeping the focus on cleaner operations in those sectors.

The revenue generated through the Cap-and-Trade auctions is deposited into the state’s Greenhouse Gas Reduction Fund, which supports a range of initiatives aimed at reducing greenhouse gas emissions (Center for Climate and Energy Solution, n.d.). These include investments in renewable energy, clean transportation, energy efficiency, and public transit, as well as funding the California Climate Investments program (Center for Climate and Energy Solution, n.d.). 35% of the revenues are legally required to be directed toward benefiting environmentally disadvantaged and low-income communities (Center for Climate and Energy Solution, n.d.; Gabriel, 2023).

To guarantee that overall emissions align with California's long-term climate goals, which include being carbon neutral by 2045, the cap is lowered annually under the Cap-and-Trade scheme (California Air Resources Board, n.d.). On this basis, the Center for Climate and Energy Solution, (n.d.) argues that California's Cap-and-Trade program serves as a backstop to ensure that the state's total greenhouse gas target is fulfilled, regardless of how well other measures perform. This argument is substantiated by data from the California Air Resources Board (CARB), (2017) report which is shown in Figure 1 below and which shows the estimated cumulation Greenhouse Gas Reduction by measures between 2021-2030. According to this 2017 report by the CARB, while other measures together will achieve a cumulative emissions reduction of 385 Metric Tonnes of Carbon dioxide equivalent (MMTCO2e), the Cap-and-Trade program alone will help achieve 236 MMTCO2e indicating that the Cap-and-Trade Program is a vital component of California's approach to decreasing greenhouse gas (GHG) emissions.

ISSN: 2347-7431
EPRA International Journal of Climate and Resource Economic Review
-Peer Reviewed Journal
Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

Figure 7: Scoping Plan Scenario – Estimated Cumulative GHG Reductions by Measure (2021–2030)



Source: (California Air Resources Board (CARB), 2017)

Germany's'Energiewende'

Energiewende' is a German word that literally means energy turnaround, transition, or transformation (Federal Ministry for Economic Affairs and Climate Action, 2015). This policy which began in 2010 is Germany's energy transition strategy which aims to transform the country into a nuclear-free economy by reaching net-zero greenhouse gas emissions by 2045 without the usage of nuclear energy (Agora Energiewende, n.d.; Clean Energy Wire, 2014). Thus, it is the country's determination to substantially alter its energy system by moving away from nuclear power and toward renewable energy sources (Federal Ministry for Economic Affairs and Climate Action, 2015). This ambitious policy, which is anchored in the 2050 Climate Change Act, aims to reduce greenhouse gas (GHG) emissions by at least 40% by 2020, 55% by 2030, 70% by 2040, and 80-95% by 2050, all in comparison to the base year of 1990 (International Energy Agency, 2020). The policy also aims to shut down the country's nuclear reactors, even though they are the primary source of carbon-free power (World Nuclear Association, 2021). These goals are supplemented by medium- and short-term targets for energy efficiency and consumption as well as the supply of renewable energy (International Energy Agency, 2020).

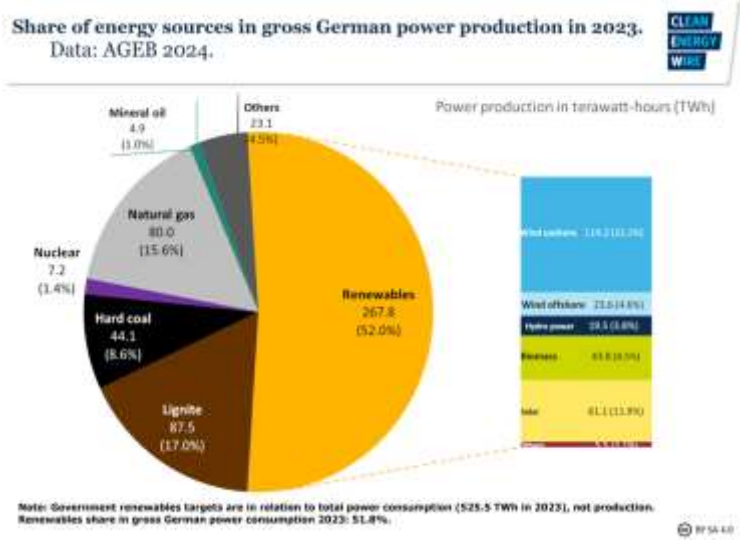
The Energiewende covers all major sectors ranging from energy, buildings, transport, industry, and agriculture, assigning specific annual emission reduction targets (Agora Energiewende, n.d.). However, transitioning Germany's energy system from fossil fuels and nuclear power to renewable energy remains the critical component of the policy (Agora Energiewende, n.d.; Federal Ministry for Economic Affairs and Climate Action, 2015). As of 2021, renewable energy accounted for 18% of primary energy consumption, up from just 1% in 1990. In the power sector in the same year, renewables covered 42% of power demand, compared to 3% in 1990 (Agora Energiewende, n.d.). However, the country realized a 38% reduction in emissions in 2021 suggesting that it was still slightly behind its goals of achieving a 40% emission reduction target for 2020 (Agora Energiewende, n.d.). In 2022, the country realized a 40.4% reduction in GHG emissions (Anderson, 2024). To accelerate this transformation, Germany planned to phase out all nuclear power plants by 2022 and increase the share of renewables in electricity to 80% by 2030 (Agora Energiewende, n.d.; World Nuclear Association, 2021). The adoption of renewable energy is essential for Germany because the power sector is responsible for about a third of Germany's GHG emissions (Agora Energiewende, n.d.). Renewable energy for that matter will help decarbonize applications like heating, cooling, and transport. As Agora Energiewende, (n.d.) notes, renewable hydrogen, for instance, could play a vital role, in decarbonizing hard-to-electrify sectors like shipping, steel, and chemical production.

A 2023 report by Bdew, (2024) highlights that more than 50% of Germany's electricity as of 2023 was produced from renewable energy sources due to the unprecedented growth of photovoltaics. CO_2 emissions of

ISSN: 2347-7431
EPRA International Journal of Climate and Resource Economic Review
-Peer Reviewed Journal
Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

the country declined by 22% in 2023 compared to 2022 levels and 57% compared to 1990 levels. Figure 2 and Figure 3 below are displayed to show the share of energy sources in gross German power production in 2023, and Renewable Power consumption in Germany from 1990 to 2023 respectively. From Figure 2, 52% of energy production in Germany as of 2023 was made from renewable. Figure 3 also highlights that 51.8% of energy consumption in Germany as of 2023 was from renewables. Germany's Energiewende is a prime example of a multifaceted, ambitious strategy to combat climate change. Although great progress has been made, much work has to be done to reach the size and pace needed to attain the 2045 climate neutrality target. However, a continuous improvement in energy efficiency will guarantee a more affordable and sustainable energy transition by further lowering expenses, emissions, and total consumption.

Figure 2: Share of energy sources in gross German power production in 2023.



SOURCE: Appunn et al., (2024)

Figure 3: Renewable Power consumption in Germany from 1990 to 2023



Source: Appunn et al., (2024).

ANALYZING THE SUSTAINABLE PRACTICES AND MOTIVATION OF THE TWO INITIATIVES.

A critical examination of the two initiatives shows that regarding California's Cap-and-Trade program, a central sustainable practice of the program is the emission cap which imposes a stringent limit on the total

ISSN: 2347-7431
EPRA International Journal of Climate and Resource Economic Review
-Peer Reviewed Journal
Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

GHG emissions that can be emitted from industries covered under the program. As businesses secure allowances, either through free allocation, quarterly auctions, or trading in the carbon market, to cover their emissions, revenue generated gets reinvested in clean technologies, renewable energy projects, and initiatives that give climate resilience.

In terms of motivations, California's Cap-and-Trade program seeks to first, mitigate climate change by cost-effectively reducing emissions (California Air Resources Board, n.d.; California Environmental Protection Agency, 2015; Environmental Defense Fund, 2020). Second, it could also be realized that the program is intended to accelerate economic innovation by promoting the development of green technologies and sustainable industries. With a financial price on carbon, the program encourages businesses to use cleaner technologies and more efficient processes. The program is also motivated by the public health benefits of reducing air pollution, which disproportionately affects vulnerable populations (Basseches, 2021).

On the other hand, Germany's Energiewende uses a number of sustainable practices as a way of achieving its climate-neutral energy goal. First, a high priority is placed on the development of renewable energy sources. Just like California, this emphasis on renewable energy is the country's deepest commitment to combating climate change, viewing the Energiewende as a crucial tool in this global fight. Moreover, the policy encourages community-owned energy projects to empower local communities to participate in and benefit from the renewable energy transition (Schmid et al., 2016).

The motivations behind Germany’s energy transition seem to be rooted in both environmental and economic priorities with combating climate change being the primary goal. Reducing reliance on fossil fuels and nuclear energy will limit environmental deterioration while enhancing energy security. Additionally, it could also be noted that the Energiewende seeks to stimulate technological innovation and economic growth within the renewable energy sector.

In sum, California’s Cap-and-Trade, and Germany’s Energiewende showcase distinct yet complementary approaches to sustainable energy and climate policy. Both initiatives demonstrate how environmental, economic, and societal goals can intersect to drive transformative change.

IMPACTS OF THE TWO INITIATIVES

California's Cap-and-Trade program

California's Cap-and-Trade program has had mixed impacts since its implementation. Environmentally, the statewide emission in California was reduced by 5.3% between 2013 and 2017 (Center for Climate and Energy Solution, n.d.). The program generally has helped the state reduce its GHG emissions by 14% since its implementation in 2013 (Gabriel, 2023). However, according to the Center for Climate and Energy Solution, (n.d). and Gabriel, (2023), this emission reduction cannot be solely attributed to Cap-and-Trade, as other state initiatives have also played important roles. While the program has been effective in incentivizing cost-effective emissions reductions at about $30 per ton of carbon dioxide equivalent (Gabriel, 2023), it has faced challenges in addressing sector-specific trends. Emissions from oil and gas are up 3.5%, and some facilities, such as Chevron Richmond Refinery, have been emitting more recently than in previous years (Lisa, 2019). Nonetheless, Lisa, (2019) also notes that the program has inspired more than 50 similar initiatives globally, suggesting that it has played a significant role in worldwide emissions reduction strategies. However, the effectiveness of the program with respect to improving local air quality is contested. Gabriel, (2023) and Rosen, (2020) found that while some studies suggest that the program has not enhanced local air quality and, in some cases, made the disparities in air pollution exposure near facilities covered under the Cap-and-Trade program worse, other studies, however, argue that the program has caused the disparities in air pollution to reduce.

Socially, the Cap-and-Trade program has also had mixed effects on communities in California, particularly low-income areas and communities already facing environmental and economic hardships. Many regulated facilities are sited in these neighborhoods, and as stated earlier, while some studies argue that disparities in air pollution have slightly improved under the program, others argue the program has worsened the air quality in these neighborhoods leaving these communities still disproportionately exposed to harmful emissions (Gabriel, 2023; Jonah, 2022; Rosen, 2020). Critics including environmental justice activists argue that the program does too little to serve disadvantaged communities since it allows polluters to keep operating without dramatic cuts in near-term emissions (Gabriel, 2023). Gabriel, (2023) further indicates that the program has

ISSN: 2347-7431
EPRA International Journal of Climate and Resource Economic Review
-Peer Reviewed Journal
Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

exacerbated gasoline prices as it has added 27 cents more per gallon which ultimately affects the wallets of lower-income households harder because they spend a greater share of their income on transportation. Notwithstanding, Rosen, (2020) argues that the program has also yielded revenues to support initiatives that benefit disadvantaged communities. According to Rosen, (2020), programs such as "Drive Clean in the San Joaquin" as part of the Cap-and-Trade program have offered residents access to cleaner vehicles, lowering transportation costs, and improving air quality in some of the most polluted regions.

Economically, the Cap-and-Trade program has proven to be a cost-effective mechanism for reducing GHG emissions. For instance, Rosen, (2020) notes that since the initial funds were issued in 2014, the auction of emissions allowances has generated billions of dollars in revenue, with almost 60%, or about $3 billion, going to underprivileged communities, significantly exceeding the legally required 35%. According to Rosen, (2020), some of these funds are used to support residents to offset electricity and natural gas costs due to the state's climate policy while the rest of the revenue goes into projects that reduce greenhouse gas emissions and improve water quality. However, the reliance on polluting industries for revenue raises ethical concerns among environmental justice advocates. This is because compliance costs are passed onto consumers, inducing economic implications such as increasing gas prices affecting all Californians, particularly those in low-income brackets (Rosen, 2020).

Germany's 'Energiewende' Policy

Germany's Energiewende policy has also had significant social, economic, and environmental impacts since its inception. Environmentally, the 'Energiewende' policy has significantly reshaped the country's energy landscape, primarily through the expansion of renewable energy sources. Oei et al., (2020) found that in 2018, the share of renewables in electricity generation increased from just 3% in 1990 to over 40%. Appunn et al., (2024), also note that in 2023, 52% of Germany's power consumption was from renewables. With this, the total greenhouse gas emission of the country has fallen by 46.1% compared to 1990 levels (Appunn, Eriksen, et al., 2024). This indicates that the 'Energiewende' has laid the foundation for achieving net-negative emissions by the country.

In terms of social impact**,** the 'Energiewende' has necessitated record-high employment levels within the renewable energy sector (Menon, 2023). However, the transition has also introduced social challenges, notably rising electricity prices, which have disproportionately affected average households and small businesses (bundesrechnungshof, 2024; Claudia, 2024). Claudia, (2024) notes that many citizens perceive the costs of the 'Energiewende' as unfairly distributed, with wealthier individuals and large corporations bearing a smaller share of the financial burden. Regional disparities also exist, with northern and eastern states benefiting more from investment opportunities and being less impacted by electricity price increases compared to other regions (Claudia, 2024). Despite these issues, the 'Energiewende' has strengthened community engagement and fostered broad participation in sustainable energy projects (Appunn, Eriksen, et al., 2024).

Economically, due to the expansion of the country's renewable energy sector, the policy has necessitated the creation of 300,000-371,000 jobs with an additional estimation of 230,000 more jobs to be created in the renewable sector by 2050 (Menon, 2023), showcasing its potential as a robust employment generator. However, the transition comes with high infrastructure costs, as expanding the electricity grid for instance will require over €460 billion in investments by 2045 (bundesrechnungshof, 2024). While these expenses pose affordability challenges, the Energiewende remains a model for sustainable economic growth and industrial innovation.

COMPARING THE TWO INITIATIVES

Juxtaposing the two initiatives, in terms of approaches, it could be seen that California's Cap-and-Trade program utilizes a market-based mechanism to help cut GHG emissions. The setting of a cap on emissions and allowing companies to trade allowances creates a financial incentive for industries to innovate and switch to cleaner technologies. This flexibility thus makes it a cost-effective tool for emissions reduction. Germany's Energiewende policy, on the other hand, reflects a more centralized model, with government directives and a thorough regulatory framework at its core. As such, it incorporates specific incentives and subsidies for sustainable investments to achieve its set of specific targets for renewable energy adoption and nuclear energy phase-out. The approach of Germany has allowed it to rapidly expand its renewable energy capacity as renewables account for more than 50% of Germany's electricity production as of 2023, showing how effective direct government intervention can be in driving large-scale transformation. On the other hand, California, although making steady progress, has depended on a larger range of measures beyond the cap-and-trade

ISSN: 2347-7431
EPRA International Journal of Climate and Resource Economic Review
-Peer Reviewed Journal
Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

program to accomplish its goals, such as energy efficiency initiatives and renewable energy regulations. This has led to a slower but more economically balanced transition.

Moreover, it could also be realized that both Initiatives have had mixed social outcomes. Although California's program has generated funds for climate-efficient projects, it has been criticized for failing to adequately address local air quality issues in disadvantaged communities. On the other hand, Germany's policy although has promoted community investment in renewable energy, critics have charged that its transition process is regionally uneven and has distributed social costs inequitably.

Environmentally, both have been quite successful, as California has achieved some reductions in emissions while Germany is on its way toward climate neutrality.

In sum, Germany's Energiewende effectively facilitates a rapid transition to renewable energy,and therefore, serves as a model of how direct government intervention can drive transformation in the quest to mitigate the impact of climate change. California's Cap-and-Trade program on the other hand also serves as an example of the importance of flexible and affordable market mechanisms in fostering sustainable practices. Both California and Germany could learn from each other's policies and adopt essential mechanisms in each other's approach that would serve them better in reaching their respective goals. For example, California might consider more direct regulation that accelerates the pace of renewable energy deployment, while Germany could consider more market-based incentives to promote cost efficiency and mitigate rising energy costs.

RECOMMENDATIONS

Considering what has been highlighted above, California's Cap-and-Trade program could be significantly improved by prioritizing investments in localized renewable energy projects like community solar initiatives and microgrids, which would deliver cleaner energy directly to underserved communities.

Also, dynamic carbon pricing, where price automatically adjusts based on real-time emissions and economic conditions, could be essential in increasing the urgency of reductions while encouraging sectors to adopt cleaner practices.

Furthermore, increasing offset restrictions to include initiatives with proven environmental benefits, such as reforestation or international renewable energy projects in poor countries, will increase flexibility while improving environmental conditions.

Concerning Germany's 'Energiewende', the country could look at investing in smart grid technologies to help address grid stability challenges by improving the integration of renewable energy sources and optimizing energy distribution (Anderson, 2024; IEA, 2023; Palensky & Kupzog, 2013). These smart grids can efficiently balance energy flow, foresee demand spikes, and handle the intermittent nature of renewable energy sources such as wind and solar (Anderson, 2024; IEA, 2023).

Also, the country could increase investment in green hydrogen infrastructure and manufacturing. This is because, green hydrogen has the potential to be a vital renewable energy storage medium and aid in the decarbonization of industries that are difficult to electrify, like heavy manufacturing, shipping, and aviation (Agora Energiewende, n.d.).

Lastly, improving community ownership models could guarantee equitable benefits from the energy transition and increase public engagement. This could be done in ways such as encouraging cooperatives or local governments to invest in renewable energy projects with financial incentives. This will strengthen communities, boost involvement in sustainability programs, and more evenly spread the transition's economic benefits.

CONCLUSION

This paper has shown that sustainability and the fight against climate change will have to be approached in various innovative ways, depending on the context. Looking into California's Cap-and-Trade Program and Germany's 'Energiewende' policy, it is obvious that both policies signify a commitment to global climate action, each offering unique pathways toward reducing greenhouse gas emissions and transitioning to cleaner energy systems. While California relies on market-based mechanisms to incentivize emissions reductions and

ISSN: 2347-7431
EPRA International Journal of Climate and Resource Economic Review
-Peer Reviewed Journal
Volume: 12 | Issue: 9 | December 2024 || SJIF Impact Factor (2024): 8.298 || Journal DOI: 10.36713/epra1213

foster innovation, Germany adopts a government-driven approach focused on regulatory frameworks and renewable energy expansion. It is also clear from the analysis that each initiative brings valued lessons and different challenges.

However, these two sustainability actions emphasize the importance of aligning climate goals with economic growth, equity, and public participation. Therefore, as global sustainability goals become increasingly urgent, integrating the strengths of different mitigation measures might offer a more balanced and effective approach. In the fight against climate change, cooperation, creativity, and the sharing of best practices are essential not only for Germany and California but the broader international community.

REFERENCES

1. *Agora Energiewende. (n.d.). What is the German Energiewende? Agora-Energiewende.Org.*
2. *Anderson, K. (2024). What is Germany's Energiewende? https://greenly.earth/en-gb/blog/ecology-news/what-is-germanys-energiewende*
3. *Appunn, K., Eriksen, F., & Wettengel, J. (2024). Germany's greenhouse gas emissions and energy transition targets. Clean Energy Wire. https://www.cleanenergywire.org/factsheets/germanys-greenhouse-gas-emissions-and-climate-targets*
4. *Appunn, K., Haas J, Y., & Wettengel, J. (2024). Germany's energy consumption and power mix in charts. Clean Energy Wire, 1. https://www.cleanenergywire.org/factsheets/germanys-energy-consumption-and-power-mix-charts*
5. *Basseches, J. A. (2021). California Cap-and-Trade: History, Design, and Effectiveness. Basseches Californi, 1–26.*
6. *Bdew. (2024). The Energy Supply 2023 – Annual Report of the BDEW – UPDATE. Bdew.De. https://www.bdew.de/service/publikationen/jahresbericht-energieversorgung/*
7. *Bigos, T. (2024). Cap and Trade: Steering Towards a Sustainable Future. EnvironBuzz Magazine. https://environbuzz.com/Cap-and-Trade-steering-towards-a-sustainable-future/#:~:text=Reduction in Greenhouse Gas Emissions, and predictable reduction in pollutants*
8. *bundesrechnungshof. (2024). Energy transition not on track: readjustments urgently needed. Bundesrechnungshof.De. https://www.bundesrechnungshof.de/SharedDocs/Kurzmeldungen/EN/2024/energiewende-en.html*
9. *California Air Resource Board. (n.d-a). Allowance Allocation. https://ww2.arb.ca.gov/our-work/programs/Cap-and-Trade-program/allowance-allocation*
10. *California Air Resource Board. (n.d-b). Compliance Offset Program. Https://Ww2.Arb.Ca.Gov/About/History. https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/about*
11. *California Air Resources Board (CARB). (2017). California's 2017 Climate Change Scoping Plan. https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf*
12. *California Air Resources Board. (n.d.). Cap-and-Trade Program. https://ww2.arb.ca.gov/our-work/programs/Cap-and-Trade-program*
13. *California Environmental Protection Agency. (2015). California Cap and Trade Program Overview. Www.Arb.Ca.Gov, 1–2. https://ww2.arb.ca.gov/sites/default/files/classic//cc/capandtrade/guidance/cap_trade_overview.pdf*
14. *Center for Climate and Energy Solution. (n.d.). California Cap and Trade. https://www.c2es.org/content/california-Cap-and-Trade/*
15. *Claudia, C. (2024). Germany's energy transition: the Energiewende. Science and Technology. https://www.meer.com/en/77779-germanys-energy-transition-the-energiewende*
16. *Clean Energy Wire. (2014). Germany's Energiewende in Brief. Clean Energy Wire (CLEW) Report. https://www.cleanenergywire.org/germanys-energiewende-brief*
17. *Environmental Defense Fund. (2020). How Cap and Trade Works. 2–5. https://www.edf.org/climate/how-Cap-and-Trade-works#:~:text=The best climate policy — environmentally,the most cost-effective ways.*
18. *Federal Ministry for Economic Affairs and Climate Action. (2015). The Energy Transition: Switch to the future. Https://Www.Bmwk-Energiewende.de/EWD/Redaktion/EN/Newsletter/2015/01/Meldung/Topthema-the-Energy-Transition.Html, 1–1.*
19. *Gabriel, P. (2023). California's Cap-and-Trade Program: Frequently Asked Questions. LOA. https://lao.ca.gov/reports/2023/4811/Cap-and-Trade-FAQs-102423.pdf*
20. *Holliman, A., & Collins, K. (2023). California's Cap-and-Trade program: is it effective in advancing social, economic, and environmental equity? Public Administration and Policy, 26(2), 128–141. https://doi.org/10.1108/PAP-06-2022-0069*
21. *IEA. (2023). Unlocking Smart Grid Opportunities in Emerging Markets and Developing Economies. https://doi.org/10.1787/3cd7a4b0-en*
22. *International Energy Agency. (2020). Germany 2020. https://www.iea.org/reports/germany-2020*

23. *Jonah, V. (2022). Is California's Cap-and-Trade program hurting the environment more than helping it? Los AngelesTimes.https://www.latimes.com/california/story/2022-03-22/what-has-california-Cap-and-Trade-accomplished*
24. *Lisa, S. (2019). Cap and Trade Is Supposed to Solve Climate Change, but Oil and Gas Company Emissions Are Up. ProPublica, 1–12. https://www.propublica.org/article/Cap-and-Trade-is-supposed-to-solve-climate-change-but-oil-and-gas-company-emissions-are-up*
25. *Menon, R. (2023). Energiewende: Germany's planned transition to a low-carbon, nuclear-free economy. Sdg16. https://www.sdg16.plus/policies/energiewende-germanys-planned-transition-to-a-low-carbon-nuclear-free-economy/*
26. *Oei, P. Y., Hermann, H., Herpich, P., Holtemöller, O., Lünenbürger, B., & Schult, C. (2020). Coal phase-out in Germany – Implications and policies for affected regions. Energy, 196. https://doi.org/10.1016/j.energy.2020.117004*
27. *Palensky, P., & Kupzog, F. (2013). Smart Grids. Annual Review of Environment and Resources, 38, 201–226. https://doi.org/10.1146/annurev-environ-031312-102947*
28. *Rosen, J. (2020). Can California's cap and trade address environmental justice? GreenBiz.*
29. *Schmid, E., Knopf, B., & Pechan, A. (2016). Putting an energy system transformation into practice: The case of the German Energiewende. Energy Research and Social Science, 11, 263–275. https://doi.org/10.1016/j.erss.2015.11.002*
30. *University of California's center for law energy and Environment. (n.d.). California Climate Policy Fact Sheet: Cap-and-Trade.*
31. *Vann Yaroson, E., Chowdhury, S., Mangla, S. K., Dey, P., Chan, F. T. S., & Roux, M. (2024). A systematic literature review exploring and linking circular economy and sustainable development goals in the past three decades (1991–2022). International Journal of Production Research, 62(4), 1399–1433. https://doi.org/10.1080/00207543.2023.2270586*
32. *World Nuclear Association. (2021). Germany's Energiewende. https://world-nuclear.org/information-library/energy-and-the-environment/energiewende*